RESEARCH, DEVELOPMENT and TECHNOLOGY TRANSFER QUARTERLY PROGRESS REPORT (QPR)

Wisconsin Department of Transportation (WisDOT)
DT1241 5/2014

INSTRUCTIONS:
Research principal investigators and/or project managers should complete a quarterly progress report (QPR) for each calendar quarter during which the projects are active.

WisDOT Research Program Category	Report Period *(enter year and check which quarter)*
☐ Policy Research ☒ Wisconsin Highway Research Program ☐ Other: _____	Year: 2014 ☐ Quarter 1 (Jan 1 – Mar 31) ☐ Quarter 3 (Jul 1 – Sep 30) ☐ Quarter 2 (Apr 1 – Jun 30) ☒ Quarter 4 (Oct 1 – Dec 31)

Project Title		WisDOT Project ID
Permeability Performance and Lateral Load for Granular Backfill behind Abutments		0092-14-03
Principal Investigator Name Pavana Vennapusa	Project Oversight Committee Chair Name Jeff Horsfall	Project Start Date (m/d/yyyy) 8/13/2013
(Area Code) Telephone Number 515-294-2395	(Area Code) Telephone Number 608-243-5993	Original End Date (m/d/yyyy) 2/12/2015
Email Address pavanv@iastate.edu	Email Address Jeffrey.Horsfall@dot.wi.gov	**Current End Date** (m/d/yyyy) 5/30/2015

Project Schedule Status *(check one)*
☐ On Schedule ☒ On Revised Schedule ☐ Ahead of Schedule ☐ Behind Schedule

Project Budget Status

Total Project Budget	Expenditures Current Quarter	Total Expenditures	% Funds Expended	% Work Completed
$150,000.00	$17,613.19	$119,334.72	80%	74%

Project Description
The current WisDOT Bridge Manual recommends using “pervious” granular backfill behind bridge abutments to prevent lateral water pressures on the abutment walls. The granular backfill material is considered “pervious” or “free-draining” based on its grain-size distribution properties. However, the “free-draining” assumption of granular backfill does not properly consider:

a) granular backfill material properties in terms of its water infiltration capacity, permeability, and water retention characteristics,
b) effect of undrained water on the lateral earth pressures exerted on the abutment walls, and
c) short- and long-term effectiveness of the pipe underdrain.

The specific research objectives of this work are to:

- Identify the current state of the practice of other state DOTs and scholarly articles addressing the influence of granular backfill permeability and water retention characteristics on the lateral earth pressure distribution and short- and long-term effectiveness of the pipe underdrain system, and collect relevant data for use in this research project.
- Conduct a thorough field investigation at 4 sites with structural backfill and granular grade 1 materials as selected by the project Technical Oversight Committee (TOC) to: (a) measure in situ permeability and water retention characteristics of the backfill materials, (b) measure in situ shear strength characteristics of the backfill materials, (c) monitor lateral earth pressures and pore pressures behind abutment walls, and (d) evaluate the performance of the pipe underdrain systems both in short- and long-term.
- Conduct a thorough laboratory investigation of the materials collected from the field sites and the alternative materials including recycled asphalt pavement (RAP) and foundry sand, to determine their shear strength, water retention, and permeability characteristics.

- Develop a practical quantitative approach to analyze lateral earth pressures on abutment walls accounting for water infiltration rate, pore pressure distribution due to infiltrated water flow, performance of pipe under drain, total unit weight, and shear strength characteristics of the backfill material.
- Develop recommendations specific to the current state of the practice of WisDOT's abutment granular backfill design and construction practices, and the impact of using alternative materials (RAP and foundry sand).

The project has been divided into the following five phases: (I) Literature Review, (II) Field and Laboratory Investigations, (III) Analysis and Evaluation of Field and Laboratory Testing, (IV) Evaluation of Alternative Materials, and (V) Final Report.

Progress This Quarter *(includes meetings, work plan status, contract status, significant progress, etc.)*
Significant progress has been made this quarter on all phases of this project. Brief details are provided below.

Phase I: The research team continued collecting relevant literature on this research. One important component of this research is to provide Wisconsin DOT a simple analytical approach to assess drainage in the backfill materials. The team is investigating an approach proposed by Casagrande and Shannon (1952), for determining time for drainage under pavements based on scaled laboratory tests. The approach is simple and requires inputs of hydraulic conductivity, cross-sectional details (width and depth of backfill), porosity of backfill, and material specific constant values. Laboratory tests have been conducted to validate the approach and develop material specific constants.

Phases II and III:

Field Testing:

Field testing and instrumentation was conducted on the final two bridge locations at Hobbles Creek Bridge in Price County, WI (Project #3) on October 6, 2014 (Figure 1) and Badger Road Bridge in Grant County, WI (Figure 2). ISU research team conducted dynamic cone penetrometer (DCP) tests at the bottom of the excavation and at the top of the backfill after all lifts were placed for both sites. Results for Hobbles Creek Bridge and Badger Road Bridge are shown in Figure 3 and Figure 4. DCP results indicate increasing CBR with depth due to confinement. Air permeability tests (APTs) and corehole permeameters were conducted at both sites. The air permeability tests for Hobbles Creek Bridge indicated a saturated hydraulic conductivity of 0.3 cm/s (822 ft./day). Corehole permeameters for Hobbles Creek Bridge were performed at 3 times with water continuously flowing to identify the change in hydraulic conductivity as saturation increased. These values can be seen in Figure 5. The initial hydraulic conductivity found to be 0.006 cm/s (16.4 ft./day) at the start of the test and after saturating for 83 minutes was found to be 0.005 cm/s (13.3 ft./day).

APTs at Badger Road Bridge indicated a saturated hydraulic conductivity of 0.70 cm/s (1984.3 ft./day). Corehole permeameter tests indicated a saturated hydraulic conducitivity of 0.06 cm/s (127.9 ft./day)

Laboratory Testing:

Laboratory classification tests (grain-size), compaction curves, and consolidation tests were performed for Schwartz Road Bridge, Hobbles Creek Bridge, and Badger Road Bridge. Grain size analysis results in comparison with project gradation specifications are shown in Figure 6. All three backfills classified as SP-SM which is poorly graded sand with silt. The percent passing the #200 sieve was 7.4% for Schwartz Road Bridge, 6.4 % for Hobbles Creek Bridge, and 1.1% for Badger Road Bridge. Schwartz Road Bridge and Hobbles Creek Bridges were compared to the specification for structural backfill in Section 210 of the Wisconsin DOT Standard Specifications. Badger Road Bridge was specified in the plans to conform to granular backfill class 1 specified in Section 209 of the Wisconsin DOT Standard Specifications.

Collapse tests were performed on backfill from the Schwartz Road Bridge, Hobbles Creek Bridge, and Badger Road Bridge. The tests were conducted using a Consolidometer with controlled overburden stresses. The tests were performed with a 1 psi seating pressure for 2 minutes and then overburden pressures of 4 psi, 8 psi, and 16 psi were applied for 2 minutes. After 2 minutes, water was introduced and change in axial strain was monitored to assess collapse. Results for the Schwartz Road Bridge are shown in Figure 6. Collapse was maximum when the moisture content of the material was at 4% (note that field moisture content ranged between 2% to 8%). Collapse results for Hobbles Creek Bridge are shown in Figure 6. Collapse was maximum of 3.5% strain change at a moisture content of 3% (note field moisture content ranged from 3% to 8 %). Collapse results for Badger Road Bridge are shown in Figure 7. Collapse was maximum at 5.7%

moisture content (note field moisture content ranged from 6% to 12%). Schwartz Road Bridge and Badger Road Bridge indicated minimal collapse, but all three show as moisture content increases beyond the optimum moisture content, collapse becomes zero.

Scaled abutment model testing has been performed on the material from all four sites and the recycled asphalt pavement (RAP). The data is being analyzed and compared to results from the numerical analysis program SEEP/W. Drainage Sock from Schwartz Road Bridge was used around the drain tile in the abutment model.

<u>Phase IV:</u>

As part of evaluating alternative materials for bridge backfill in Wisconsin, recycled asphalt pavement (RAP) and recycled asphalt shingles (RAS) materials were obtained from Mathy Construction Co. quarries near Onalaska, WI. RAS had an initial fines 18%. The material was re-graded and sieved to a fines content of 2.5% and conforms to Standard 210 for structural backfill in the Wisconsin DOT Standard Specifications. Figure 8 shows the before and after gradations of the RAS. The re-graded material is currently being used in lab tests including compaction, direct shear, and collapse. Collapse tests have been completed on the RAP.

Anticipated Work Next Quarter

The following activities are anticipated during the next quarter

1. Continue laboratory testing and analyze field instrumentation results.
2. Perform laboratory bridge abutment model tests using material bridge sites to calibrate numerical models.
3. Complete data analysis and associate write-up.
4. Submit draft final report to TAC.

Circumstances Affecting Project or Budget

None.

Figure 1. Hobbles Creek Bridge Abutment in Price County, WI

Figure 2. Badger Road Bridge, Grant County, WI

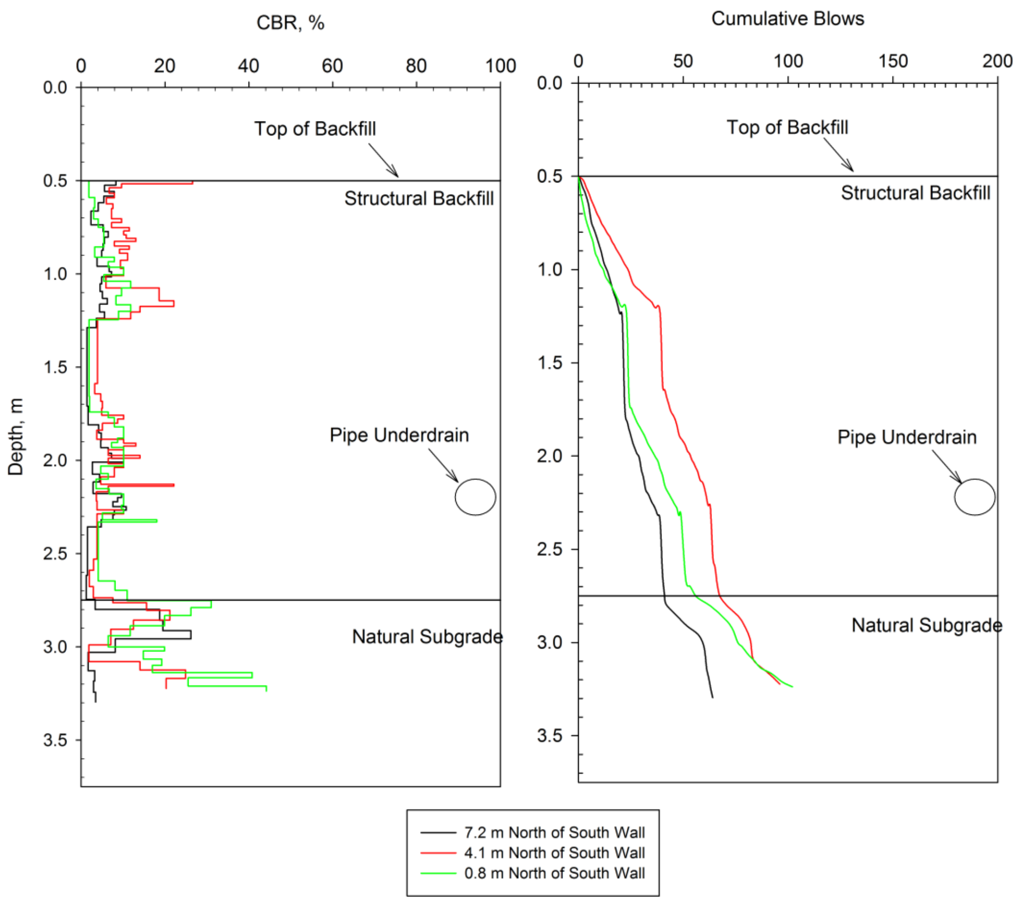


Figure 3. DCP test results for Hobbles Creek Bridge

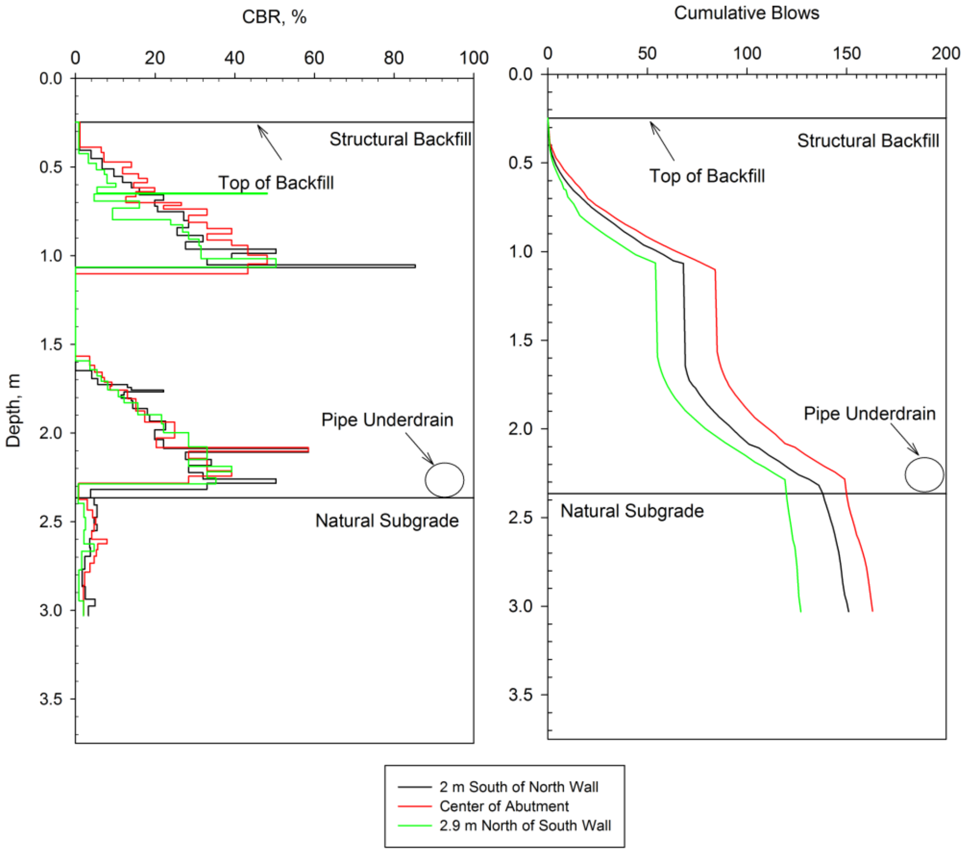


Figure 4. DCP test results for Badger Road Bridge

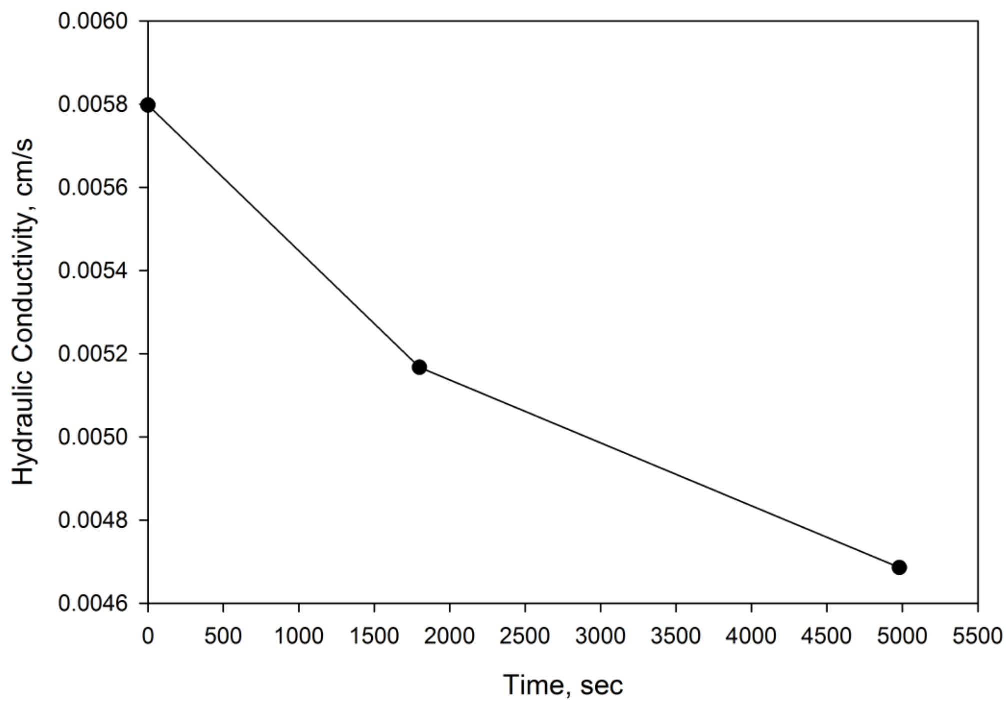
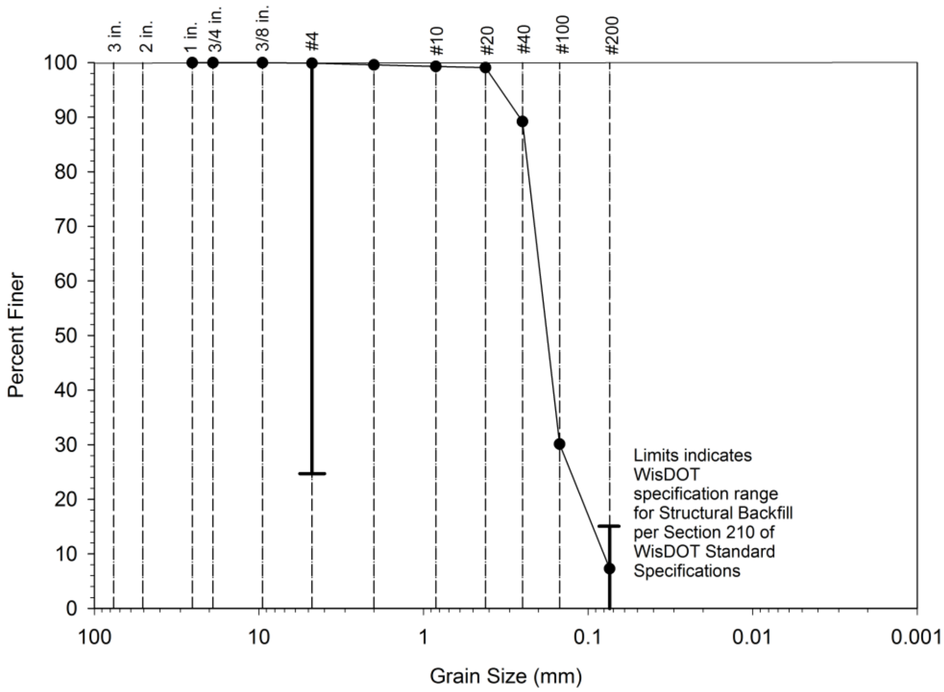


Figure 5. Saturated hydraulic conductivity with time for Hobbles Creek Bridge


3 in.
2 in.
1 in.
3/4 in.
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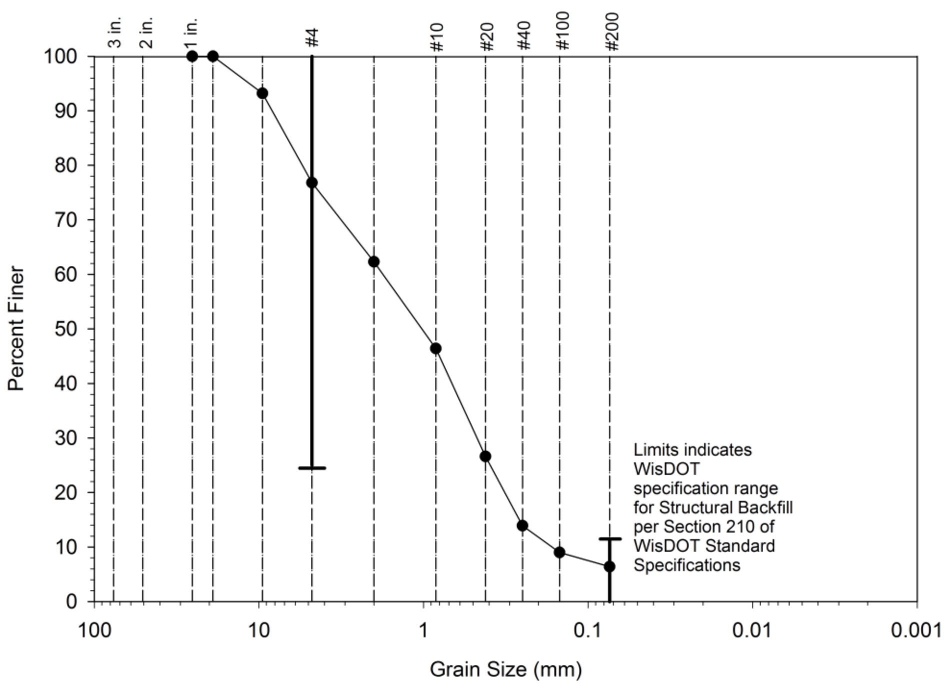
#20
#40
#100
#200
Percent Finer
Grain Size (mm)
Limits indicates
WisDOT
specification range
for Structural Backfill
per Section 210 of
WisDOT Standard
Specifications

(a)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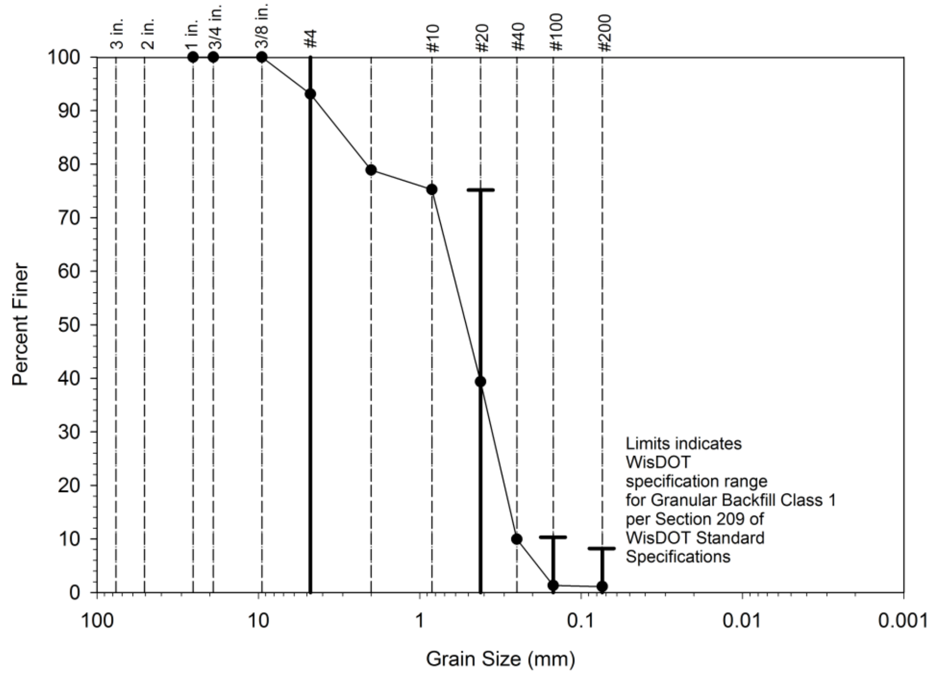
#100
#200
Percent Finer
Grain Size (mm)
Limits indicates
WisDOT
specification range
for Structural Backfill
per Section 210 of
WisDOT Standard
Specifications

(b)



(c)

Figure 6. Gradation analysis for Schwartz Road Bridge (a), Hobbles Creek Bridge (b), and Badger Road Bridge (c)

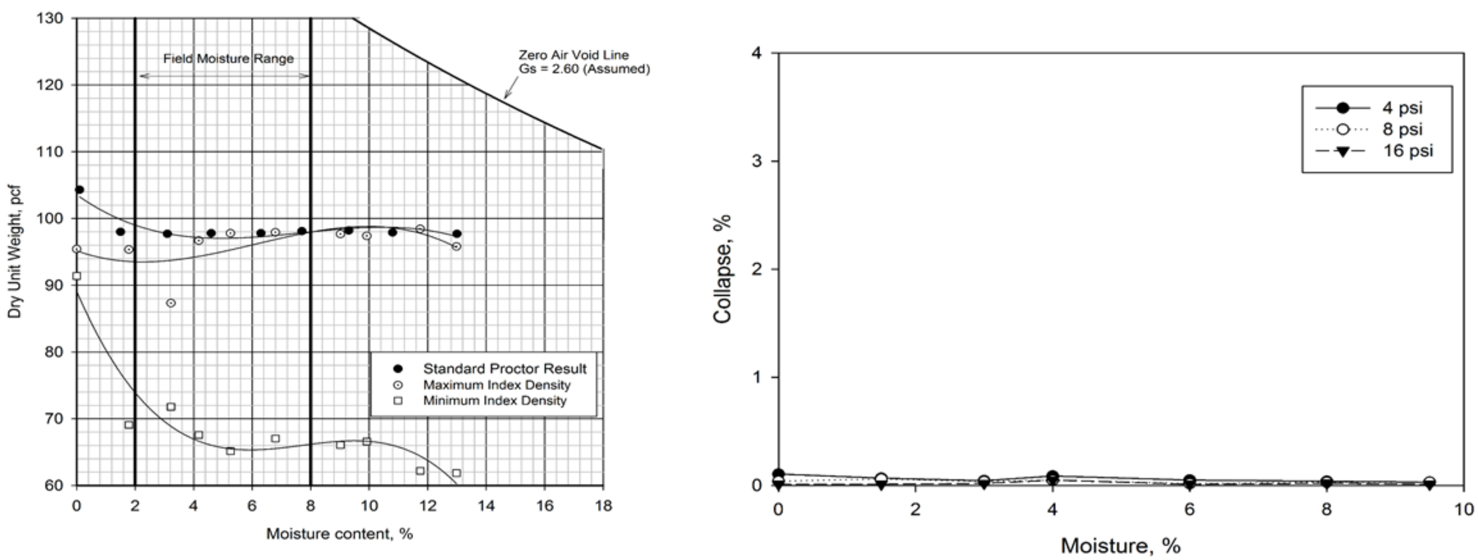


Figure 7. Compaction and collapse results of Schwartz Road Bridge

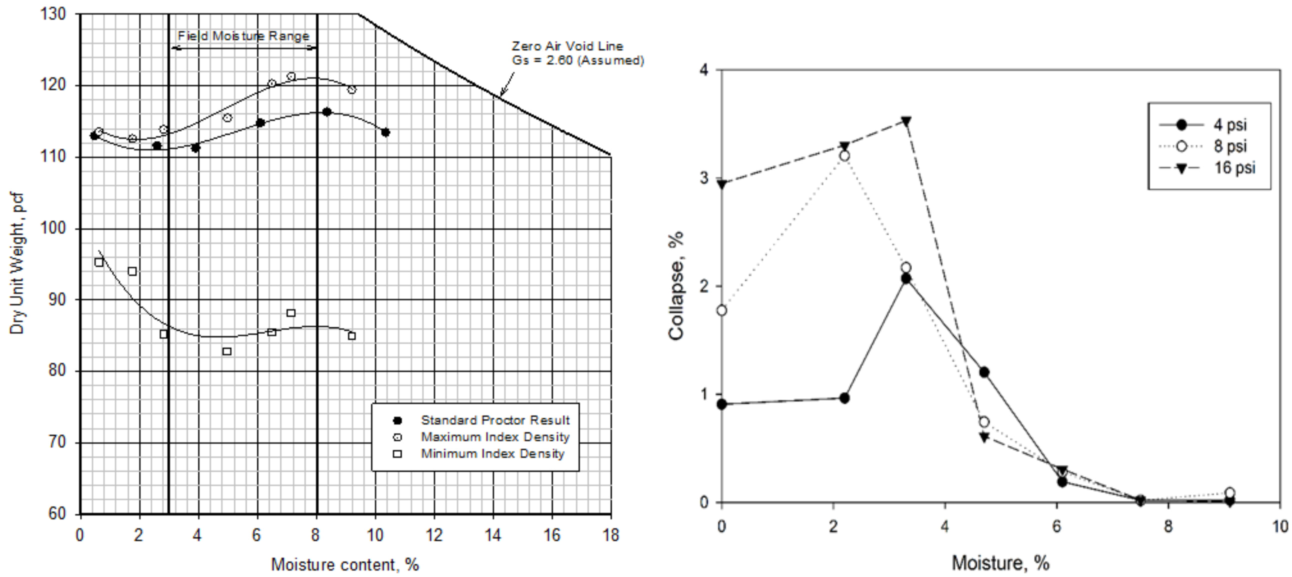


Figure 8. Compaction and collapse results for Hobbles Creek Bridge

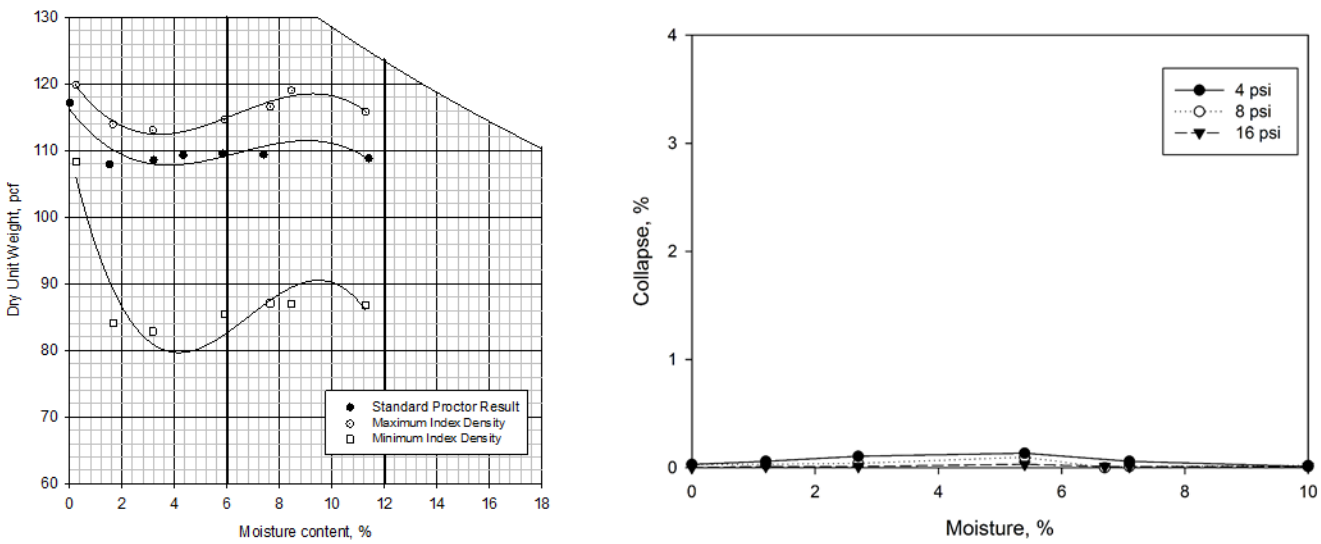


Figure 9. Compaction and collapse results for Badger Road Bridge

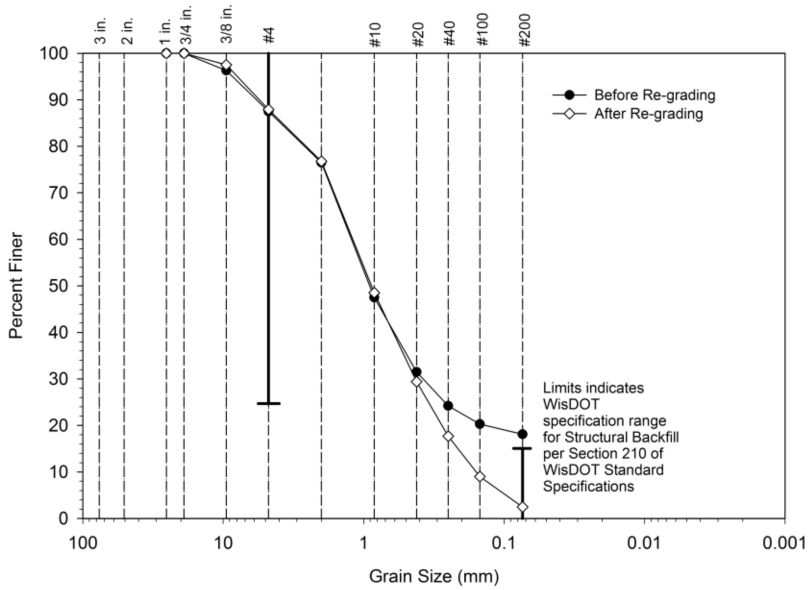


Figure 10. Before and after re-grading RAS

Attach / Insert Gantt Chart and Other Project Documentation

	MONTH																		
	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15
Phase I																			
Phase II																			
Phase III																			
Phase IV																			
Phase V																			
TOC Review, Revision, and Final Submission																			

*(*enter text)*

For WisDOT Use Only	
Staff Receiving QPR J. Walejko	Date Received (m/d/yyyy) 1/9/2015
Staff Approving QPR Jeff Horsfall	Date Approved (m/d/yyyy) 2/3/2015